Research Brief

RESEARCH PROGRAM ON Roots, Tubers and Bananas

CGIAR

Banana Fusarium Wilt Tropical Race 4:
How has Bioversity International contributed to saving the Philippines' banana industry?

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INTRODUCTION

Bananas are of huge importance to the Philippines economy, particularly in the region of Mindanao, which is the main exporter of sweet Cavendish bananas – the kind sold in supermarkets worldwide. Filipino bananas comprise 90% of Asia's banana exports (FAO2017_banana), and Cavendish cultivars worldwide represent 16% of the global export market, at a value of well over US$ 1 billion. Cavendish plantings cover more than 80,000 hectares in the Philippines. The national export industry directly employs about 320,000 people, 70% of whom work for large corporate growers, and 30% as small-scale farmers.

The export industry is, however, vulnerable to disease since it depends on just a single cultivar subgroup- Cavendish- grown in monocultures. In the early 2000s, the Philippines economy was threatened with huge losses by a deadly disease that began to spread through the Cavendish populations: Fusarium wilt of banana caused by the fungus *Fusarium oxysporum* f.sp. *cubense* Tropical Race 4 (*Foc* TR4). If uncontrolled, *Foc* TR4 could potentially wipe out the whole banana industry in these islands, with devastating effects on local communities.

The problem when breeding and growing bananas is that commercial bananas, like the Cavendish, have no seeds. They can only be grown as clones from a parent plant (e.g. from corms or suckers). This makes them very vulnerable to diseases especially when grown in swathes of perennial monocultural systems. However, sometimes clones naturally mutate especially in production systems using tissue-cultured plantlets. Such mutants differ from the parent material, for example having stronger resistance to certain diseases. Because these mutant clones arise from ordinary (somatic) tissues, and not via any sexual reproduction, they are called somaclonal variants or somaclones.

Two such somaclones are i) Giant Cavendish Tissue Culture Variants (GCTCV) 218 developed and selected by the Taiwan Banana Research Institute (TBRI), from tissue-culture variants of cultivar Pei Chiao, registered with the cultivar name 'Formosana' and ii) GCTCV 219 selected from Philippines company Lapanday Foods trials by the leading Bioversity scientist. Both display some level of Fusarium wilt-resistance. While they maintain the quality and agronomic characteristics that make Cavendish bananas so popular, they are more resistant to *Foc* TR4 than other commercially popular Cavendish cultivars.

This brief describes how Bioversity International coordinated participatory research with farmers and worked with many different partners to promote the widespread uptake of these disease-resistant somaclones, GCTCV 218 and GCTCV 219, and avert a possible collapse of the Philippines banana export industry.

LEARNINGS

The importance of location when evaluating varieties

GCTCV 218 had been tested in Australia and South Africa in the early 2000s but not rated very highly. However, when planted in the Philippines, there were different results, which were highly acceptable to both banana producers and banana consumers. This clearly illustrates the importance and value of using multi-location trials to assess genotype X environment (GxE) interactions

Somaclones may offer a swifter path than GMOs to farmer-approved resistant varieties

As a seedless clonal crop, bananas face difficulties in creating new cultivars. For this reason, many industry funders focus on the potential of genetically-modified organisms (GMOs) to produce *Foc* TR4-resistant bananas. While GMOs undoubtedly hold promise, they have not yet yielded a TR4-resistant banana cultivar. A currently swifter path to support people's livelihoods is offered by selecting naturally occurring somaclones with TR4-resistance, then testing them for acceptability with consumers and producers. However, the emergence of highly specific Crispr gene-editing technology may eventually replace this random somaclonal variant selection process.

The importance of multi-stakeholder partnerships

The new resistant varieties that were trialed, particularly GCTCV 218, were well received by small-scale banana farmers. An additional valuable outcome emerged from a greater-than-expected participation of the private sector, including Dole-STANFILCO, Tagum Development Corporation, Del Monte Philippines and the Lapanday Food Corporation. The latter has been involved since the very beginning in producing planting material. Through a private–public partnership, the Department of Agriculture has consequently taken on responsibility for distribution. The involvement of the public sector has resulted in increased public visibility of the initiative and strengthened capacity of all involved. This have been supported by peer learning from the Farmer Field Days, as well as scientific publications and visibility in the academic sector at international level.

WHAT WE DID

Step 1: Identify the disease

Cavendish bananas had been popular since the 1950s because the group of cultivars is resistant to the Race 1 strain of Fusarium Wilt, that virtually wiped out the then popular Gros Michel cultivar. Cavendish became the standard replacement of Gros Michel in all big commercial plantations worldwide, having equivalent consumer acceptability. However in the late twentieth century outbreaks of a new virulent strain of Fusarium wilt (TR4) destroyed plantations in Taiwan (1967), Indonesia, and Malaysia 1990, and subsequently Australia (1997), and China (2000).The Philippines had escaped the disease, until in the early 2000s as suspected cases began to crop up in the highland regions. The first step was to engage the banana industry, government regulatory agencies, the Philippines Bureau of Plant Industry and experts at Stellenbosch University in South Africa to study the disease in order to develop plans for disease prevention and mitigation.

Step 2: Farmer evaluation of banana somaclones

In 2004, Bioversity International began collaborative research through its regional network, the Banana Asia Pacific Network (BAPNET) by engaging the TBRI to share its *Foc* TR4-resistant somaclones via Bioversity's International *Musa* Germplasm Transit Centre (ITC).The team evaluated seven TBRI somaclones in different BAPNET member-countries, with a special focus in the Philippines where the epidemic was most severe and widespread in Cavendish plantations. The team engaged government agencies and the industry sector in evaluating the TBRI somaclones. The Philippines Council of Agriculture, Aquatic Resources Research and Development (PCAARRD) funded replicated evaluation trials that were coordinated by state universities and government research institutions. The first year saw 20 independent farmers involved, with 20 more participating per year in the next two years. The Institute of Plant Breeding at Los Baños sourced the planting material for the farmers from a private company, Lapanday Foods Corporation, multiplied it via tissue culture (TC), so that there were enough TC plantlets for planting, and the regional crop protection center at Davao distributed the planting material to farmers.

Once the new plants had produced bananas, the farmers were asked to rate the new somaclones for resistance to Foc TR4, and also for the quality of the fruit, of fundamental importance to sales. Farmers found that GCTCV 219 and GCTCV 218 were by far the favorites.

- GCTCV 219 is highly resistant to *Foc* TR4, but has a lower commercial value because it takes longer to produce fruit and produces fewer bananas per stem than GCTCV 218. On the other hand, it is sweeter than regular Cavendish, so can be marketed as a premium banana.
- GCTCV 218, registered as *Formosana* is a little less resistant to *Foc* TR4 than GCTCV 219, but commercially more viable as it is very similar to *Grande Naine*, the current standard commercial Cavendish cultivar.

Step 3: Outscaling

The Department of Agriculture Bureau of Agricultural Research (DA-BAR) was a key partner for outscaling these two more popular cultivars, working closely with big companies and small growers. The results of these semi-commercial trials led the team to conclude that GCTCV 218 was ultimately more acceptable both to consumers and markets and to production stakeholders

Step 4: Enhancing the capacities of small-scale Cavendish banana farmers

Getting the *Foc* TR4-resistant material to farmers was not enough on its own. Managing diseases is a complicated business involving not

only participatory varietal selection, but also integrated pest management (IPM) practices to manage and eradicate infected plants. In addition to trialing the new somaclones, the multidisciplinary team also built local capacity to research and manage *Foc* TR4. The package of complementary disease control measures adopted to support using the TR resistant somaclones, included disease suppressive soils and biocontrol agents, interplanting with allium, quarantine, disinfecting protocols and so on The team organized Farmer Field Days-learning events where farmers could participate in exhibitions, demonstrations, and discussion spaces, and learn from peers and experts. Over 120 people participated across two events (2013 and 2014), from farmer cooperatives to researchers, government agencies and private industry. Building on these activities, the team continued to work closely with farmers to help them collect data, monitor success on farm and report back. Coordinated by Dr Molina of Bioversity, the capacity building initiatives were supported by DA-BAR.

Step 5: Supporting continued use

To support the farmers, local technical staff were briefed on the latest *Foc* TR4 management tips and developments, with guidelines and information sheets, and participation in conferences and seminars on the subject. A public awareness campaign, using local magazines and newspapers, spread the word on *Foc* TR4 risks and management, and the use of disease-resistant somaclones.

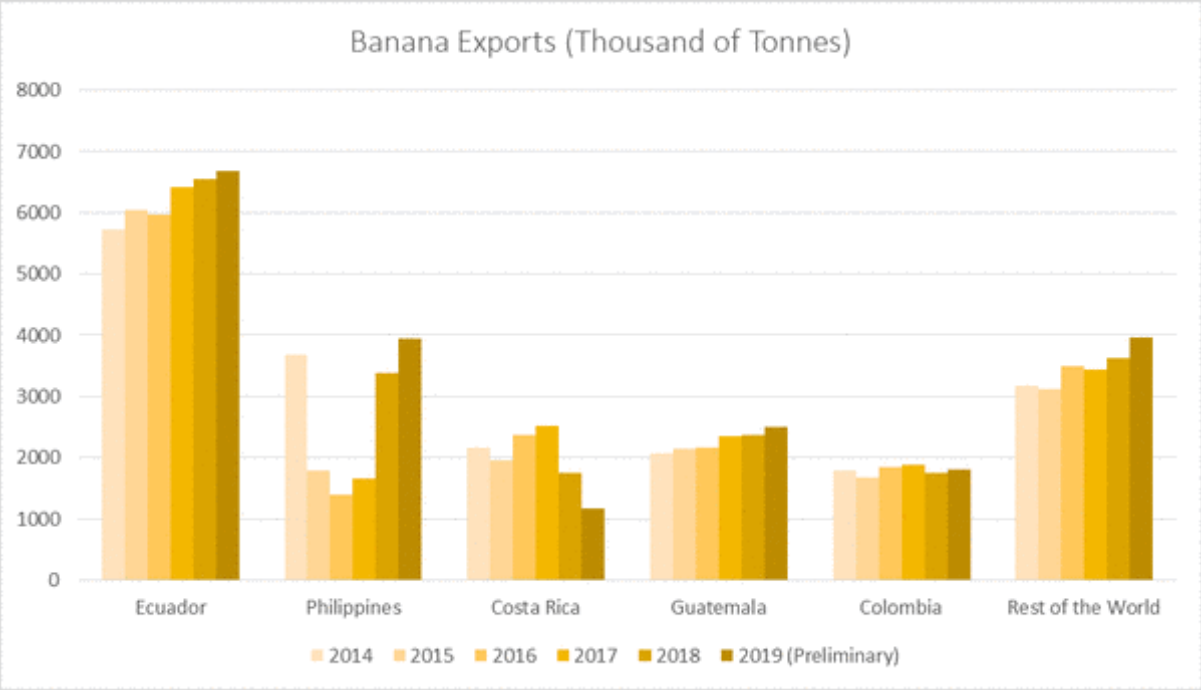

Figure x: Global banana exports from top producing countries between 2014-2019, showing the effects of Foc TR4 on Philippine banana production, and reinvigoration of the industry. Source: FAO (EST)

Project partners:

- Bureau of Plant Industry – Davao National Crop Research for Development Center (BPI – DNCRDC)
- the Department of Agriculture of Region XI
- Farmers, Farmer Associations and Farmer Cooperatives
- Lapanday Food Corp
- Institute of Plant Breeding, Crop Science Cluster, University of the Philippines, Los Baños
- Dole-STANFILCO
- Tagum Development Corporation (TADECO)
- University of Southern Philippines (USEP)
- BAPNET – TBRI, Australian Centre for International Agricultural Research/Department of Agriculture and Fisheries (ACIAR/DAF), Indonesian Fruit Research Institute (ITFRI)
- Stellenbosch University
- Department of Agriculture Bureau of Agricultural Research (DA-BAR)
- Philippine Council of Agriculture, Aquatic Resources Research and Development (PCAARRD)
- Pilipino Banana Growers and Exporters Association (PBGEA)
- Mindanao Banana Farmers and Exporters Association (MBPFEA)

WHAT IMPACT DID WE HAVE

Now more than 10,000 hectares are planted to the GCTCV 218 somaclone (Formosana) in the Philippines and the area is expanding. All new plantings use this cultivar.

More and more banana producers shifted to growing GCTCV 218 despite its only moderately-resistant rating, including several commercial banana farmers. The project started distributing planting materials to farmers collaborating in the project. To date, 120,000 plantlets have been distributed to 249 banana growers in the Davao Region and Compostela Valley Province.

Through the leadership of Bioversity International in collaboration with Lapanday Foods Corporation, the Region XI Department of Agriculture purchased more than 1.3 million plantlets of GCTCV 218 that will cover approximately 8,000 hectares of banana farms of small banana growers. Another important impact is that Lapanday Foods provided clean, tissue-cultured, TR4-resistant plantlets to local smallholders at cost. This win-win scenario reduced the overall risk of local TR4 spread because it allowed neighboring smallholders the means to effectively combat the disease, at the same time protecting the adjoining large banana plantations.

Bioversity International scientist and research leader Agustin Molina was rewarded for the results of this research with an Award of Recognition from the PBGEA and PhilExport at the International Banana Congress in 2018.

TR4 was identified for the first time in the Cavendish-dependent Latin American and Caribbean region in Colombia in 2019. Unless growers adopt strict measures developed in other regions, their export production, particularly in Ecuador, could be compromised, as it was in the Philippines (see Figure x).

Acknowledgements:

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We would also like to acknowledge the central role of leading ex-Bioversity Senior Scientist Dr Gus Molina, and also Ms Vida Sinohin, without whose inputs the work would not have been possible. Finally, we would like to acknowledge ACIAR for their historical role in supporting regional TR4 research.

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